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A New Species of *Forreria* (Gastropoda: Muricidae: Ocenebrinae) from the Sea of Cortez, Mexico

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ABSTRACT A new muricid is described from deep water in the Wagner Basin, in the northern Sea of Cortez, Mexico, 65 kilometers south of Puerto Peňasco, Sonora, Mexico. The only living relative of this new species is *Forreria belcheri* (Hinds, 1843), which ranges from Santa Barbara, California, to Laguna Scammons, Baja California, Mexico. This new endemic species has been brought to light by shrimp trawling activities, and is thought to be a relict deep water population left behind in the northern Sea of Cortez during the Pleistocene.

KEY WORDS *Forreria*, *F. belcheri*, *F. corteziana* n. sp., Sea of Cortez, relictual species

INTRODUCTION

In the 20th century, many workers conducted extensive field work in the Sea of Cortez and made discoveries of previously unknown species in these tropical Panamic Province waters. Many of the new species were brought to the attention of science by shrimp trawlers who fished the area west of Guaymas, Sonora, Mexico. Despite over 150 years of extensive research in the Sea of Cortez, including a lifetime of work by Dr. Hans Bertsch off Bahía de Los Ángeles, Baja California, Mexico, the deep water basins of the northern part of the Sea of Cortez remain largely unexplored (Bertsch & Rosas, 2016). Recently an interesting large muricid was found by shrimp trawling activities in the Wagner Basin off Puerto Peňasco, Sonora, Mexico, some 550 kilometers northwest of Guaymas. (*see* Figure 1 for map of the northern Sea of Cortez) This large and interesting muricid is recognized here as a new species of *Forreria*, related to *F. belcheri* (Hinds, 1843), which inhabits the temperate waters of the Californian Province (Berschauer & Clark, 2018). Evidence suggests that this new deep water muricid represents a relictual population that evolved from *F. belcheri* during periods of reproductive isolation due to lowered sea levels during the Pleistocene.

Abbreviations. Type specimens of the *Forreria corteziana* Berschauer, Petuch and Clark, new species, are deposited in the following institutions:
LACM = Natural History Museum of Los Angeles County; Los Angeles, CA
SBMNH = Santa Barbara Museum of Natural History; Santa Barbara, CA
CASIZ = California Academy of Sciences; San Francisco, CA
ANSP = Academy of Natural Sciences of Drexel University; Philadephia, PA

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BMSM - Bailey-Matthews National Shell Museum; Sanibel, FL
USNM = Smithsonian National Museum of Natural History; Washington DC
MNHN = Musèum National d'Histoire Naturelle; Paris, France

Figure 1. Map of the northern Sea of Cortez, Mexico, showing the approximate location of the Wagner Basin with a red circle.

SYSTEMATICS

Class Gastropoda
Subclass Sorbeoconcha
Order Prosobranchia
Infraorder Neogastropoda
Superfamily Muricoidea
Family Muricidae
Subfamily Ocenebrinae
Genus *Forreria* Jousseaume, 1880

Forreria corteziana Berschauer, Petuch and Clark, new species
(Figure 2 A-C; Figure 3 A-F)

Description. Medium to large sized shell, white protoconch proportionately large composed of three bulbous whorls, seven to eight teloconch whorls, spinose on shoulder, relatively high spire, narrow shoulder which tapers to sharp bend below aperture, long open siphonal canal which is more than one-third body length, siphonal canal slightly recurved, small open umbilicus, sharp suture between whorls; shoulder bears seven to eight relatively long, open, delicate spines formed from blade like varix protruding from upper third of body whorl approaching shoulder; spines guttered and rounded at back, pointing mostly upwards; light tan to white body color often with muted peach to pink longitudinal markings; apex white; aperture smooth and bright white; body whorl almost smooth, bearing weak microsculpture consisting of flattened smooth radial cords crossed by weak growth lines; outer lip smooth, weak spiral groove on body whorl which terminates in small labral tooth which appears to be vestigial. Operculum large, brown, D-shaped, filling aperture, with concentric growth lines, nucleus lateral; interior surface with C-shaped callous, broad and thick on outside edge, thinning dramatically on anterior and posterior edges; interior area with irregular vermiform costae.

Type Material. In addition to the type material a total of twenty seven specimens were examined.
HOLOTYPE: LACM 3601, length 91.7 mm.
PARATYPES:
No. 1 - LACM 3602, length 101.2 mm.
No. 2 - SBMNH 166000, length 79.3 mm
No. 3 - CASIZ 224327, length 83.2 mm
No. 4 - ANSP 476376, length 89.8 mm
No. 5 - BMSM 125552, length 88.5 mm

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No. 6 - USNM 1490908, length 75.5 mm
No. 7 - MNHN IM-2014-6953, length 76.8 mm

OTHER MATERIAL EXAMINED: Twelve specimens, 82.4 to 104.0 mm in the research collection of David P. Berschauer; two specimens, 81.0 mm, and 92.0 mm in the research collection of Edward J. Petuch; four specimens, 76.5 to 98.6 mm in the research collection of Roger N. Clark; one specimen, 89.3 mm, in the collection of David B. Waller.

Type Locality. Trawled from 140 m depth, in a restricted 20 km area, at the bottom of the Wagner Basin, in the northern Sea of Cortez, Mexico, 65 km south of Puerto Peňasco, Sonora, Mexico.

Distribution. Known only from the type locality, the Wagner Basin, Sea of Cortez, Mexico.

Size Range. Adults 75 to 104 mm in length. Typically from 80 to 90 mm in length.

Ecology. The new species was trawled by shrimpers in a deep water basin at 140 m on a black muddy-silt bottom. Based upon the small, almost vestigial labral tooth, the authors presume that it feeds exclusively on thin shelled bivalves which inhabit the basin. The new species may also be a scavenger in similar fashion to other known deep water muricids.

Etymology. Named for the Sea of Cortez, the geographic region where this species is found.

Discussion. *Forreria corteziana* n. sp. is closest to *F. belcheri*, a Californian Province species, from which it is easily separable. *F. belcheri* has overall a heavier shell, a broader shoulder, ten to twelve knob-like spines on the shoulder, and a shorter siphonal canal. (*see* Figure 2 D-E). In contrast, *F. corteziana* has a thinner lighter shell, with a narrower shoulder, seven to eight relatively long delicate spines, a substantially longer and thinner siphonal canal, and a smaller labral tooth. Finally, the type of genus, *F. belcheri*, has a deep spiral groove in the body whorl which terminates in a large well formed labral tooth on the outer lip (Kool, 1993; Vermeij, 2001), whereas *F. corteziana* has a weak spiral groove which terminates in a small labral tooth (Figure 4). None of the ten or so fossil species of *Forreria* from California or northern Baja California, Mexico, have the long delicate shape of *F. corteziana* n. sp. or are remotely similar in appearance (Vermeij, 2001; Powell, 2005; Charles L. Powell, II, personal communication) Figure 3 illustrates three specimens to show some of the variability in this new *Forreria* species.

An interesting ecological note is that almost every individual of *Forreria corteziana* n. sp. (and other muricid gastropods such as *Pteropurpura centrifuga* (Hinds, 1844)) brought up by the shrimp trawler from the Wagner Basin had one or two live anemones on the back of its shell, often wrapped around the long spines (Figure 5). The species of anemone appears to be *Anthothoe carcinophila* (Verrill, 1869), and may have either an ectocommensal or mutualistic relationship with the gastropod; *see* Brusca, 1980.

Geological and Oceanographic History.

The new *Forreria* species is confined to the Wagner Basin, a small but deep depression at the northern end of the Sea of Cortez (also known as the Golfo de California) off Sonora, Mexico. The geometry, configuration, and bathymetry of this deep basin is an artifact of the intense geological activity that is associated with the rifting and opening of the Sea of Cortez. This northernmost basin formed as a downdropped block between two parallel

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normal faults (the Wagner Fault to the east and the Consag Fault to the west) and a perpendicular transform fault system (the Ballenas Transform Fault to the south) in a pull-apart basinal structure. The Wagner Basin is also the southernmost end of the Cerro Prieto strike-slip system and is tectonically highly active (Gonzalez-Escobar *et al.*, 2009). Although the Sea of Cortez rift zone began forming around 6 million years ago (Messinian Age, Miocene), the Wagner Basin is one of the most recent geological structures to form, with its subsidence taking place only around 2 million years ago (Gelasian Age, Pleistocene) (Persaud *et al.*, 2003). Since that time, the sea floor within the small basin has dropped to over 250 m depth, generating a deep oval-shaped pocket within an area of shallower continental shelves, averaging only 25-75 m depths.

During the Early Pleistocene, the newly-formed Colorado River acted as a source of muddy, organic-rich sediments that filled much of the basin. The Colorado River was, and still is, also a source of fresh water effluent, forming a massive delta system between modern San Felipe and Puerto Peňasco. This delta system helped to preserve the marine environments of the Wagner Basin during the climatologically-catastrophic time of the Gelasian-Calabrian Age boundary, around 1.2 million years ago. During this glacially-induced cold time, sea levels dropped as much as 100 m, well below the depth of the shallow San Pedro Martir Sill, which extends from Isla Tiburon to Isla San Esteban in the northern one-third of the Sea of Cortez. This emergent sill effectively created two separate seas, with only the southern section having a direct connection to the Pacific Ocean. The northern section, which contained the Wagner Basin, became an isolated salt water lake and its resident organisms were cut off, reproductively, from their congeners to the south. Due to the surrounding extreme desert conditions and high levels of evaporation, this isolated salt lake should have degenerated into a series of salt flats and brine pools, completely destroying the marine ecosystems that resided there. These extreme oceanographic conditions, however, failed to materialize during this time, primarily due to the continual input of fresh water from the Colorado River Delta. This kept the salinity at normal levels and allowed many of the original resident organisms to persist on within this geographically-small isolated inland sea.

As sea levels were dropping at the end of the Gelasian Age, the Eastern Pacific water temperatures also were lowered drastically as the main oceanic basin began to cool and accumulate sea ice at higher latitudes. These cooler water conditions would have allowed numerous cold-tolerant Californian genera to migrate down the outer coast of the Baja California Peninsula and enter the Sea of Cortez. Just prior to the emergence of the San Pedro Martir Sill in late Gelasian time, these Californian migrant genera apparently became established within the Wagner Basin, living on the organic-rich sea floors that were now established in the central deeper water area.

The resultant reproductive isolation, due to the formation of the inland sea, resulted in the evolution of several endemic species that were offshoots of widespread Californian Province gastropod genera. Some of these include the ocenebrine muricid *Forreria* and its endemic offshoot *F. corteziana* n. sp. and the fasciolariid genus *Hesperaptyxis* and its locally-restricted offshoots *H. felipensis* (Lowe, 1935) and *H. fredbakeri* (Lowe, 1935). These two California-based genera, and their endemic northern Sea of Cortez species, occur together with other highly-restricted endemic taxa, such as the tropically-derived ranellid *Turritriton gibbosus adairense* (Dall, 1910), the cypraeid

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Macrocypraea cervinetta californica Lorenz, 2017 (recently described and illustrated as a new subspecies in Lorenz, 2017 on p. 290), the olivid *Americoliva corteziana* (Petuch and Sargent, 1986), the muricid *Eupleura limata* Dall, 1890, and the calliostomatid *Calliostoma palmeri* Dall, 1871. Another relict taxon which was similarly left behind to the northern Sea of Cortez during the Pleistocene is the bursid *Crossata sonorana* (Berry, 1960), which is virtually indistinguishable from a morphological form of its sister taxon *C. californica* (Hinds, 1844), although genetic testing of these two sister taxa remains to be conducted. (Powell & Berschauer, 2017). These endemic species apparently evolved within the isolated Pleistocene inland sea and have persisted on into the Recent as relict taxa in the northernmost Sea of Cortez. The cold-water genus *Forreria* has apparently found a refugium in the deep, cooler waters of the Wagner Basin, where it survives as a fragile, limited population within a very limited geographic area and narrow bathymetric range.

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Figure 2. A, B, C = *Forreria corteziana* Berschauer, Petuch & Clark, new species, holotype LACM 3601, 91.7 mm in length,Wagner Basin, trawled at 140 m depth in the northern Sea of Cortez, Mexico; **C, D** = *F. belcheri* (Hinds, 1843), specimen from the collection of the senior author measuring 109.6 mm in length, from Newport Bay, California.

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Figure 3. A, B = *F. corteziana* Berschauer, Petuch & Clark, new species, specimen from the collection of the senior author measuring 82.4 mm in length from the same locality as the holotype; **C, D** = *F. corteziana* Berschauer, Petuch & Clark, new species, specimen from the collection of the senior author measuring 82.9 mm in length from the same locality as the holotype; **E, F** = *F. corteziana* Berschauer, Petuch & Clark, new species, specimen from the David B. Waller collection measuring 89.3 mm in length from the same locality as the holotype.

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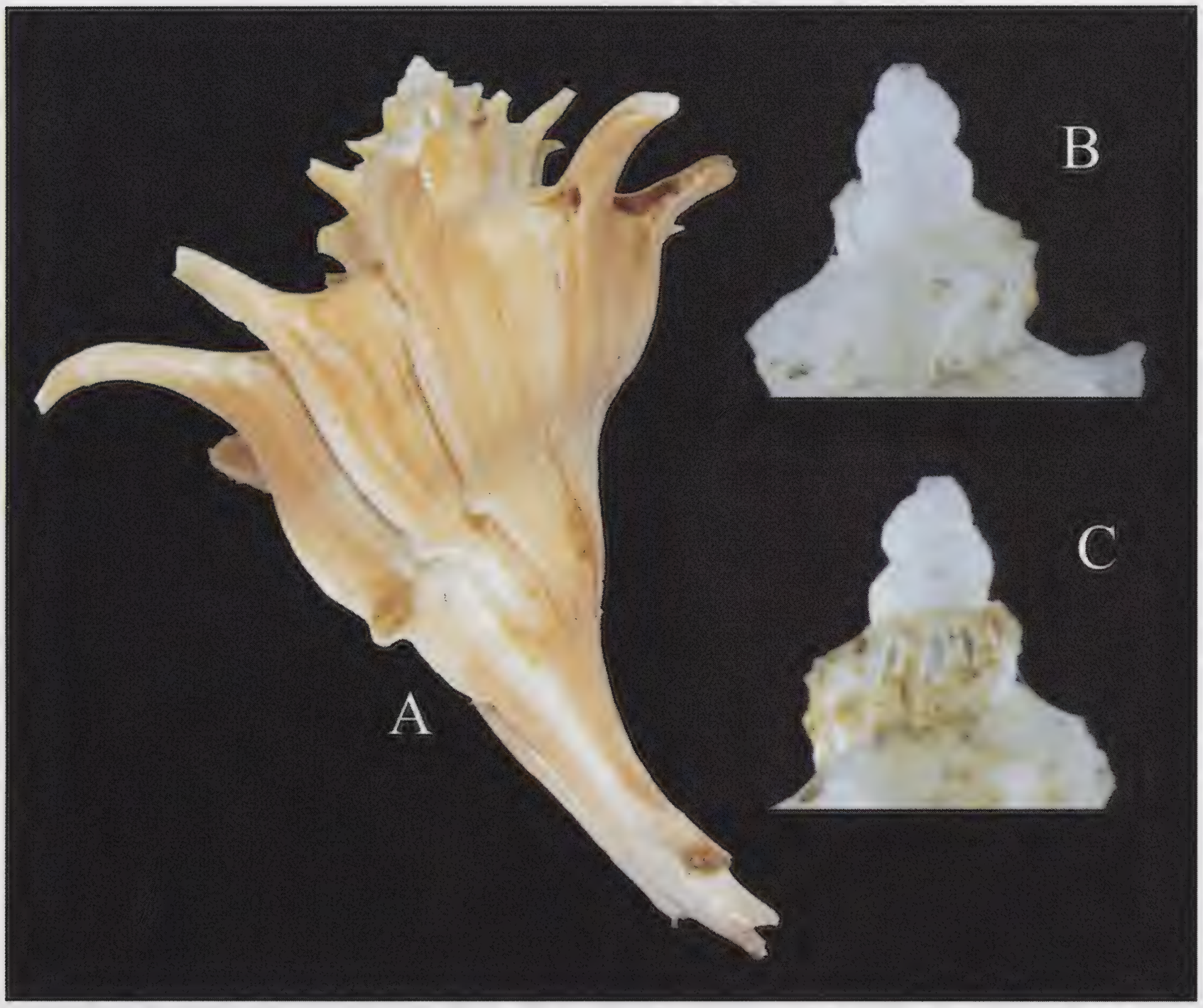

Figure 4. *F. corteziana* Berschauer, Petuch & Clark, new species: **A** = weak spiral groove on body whorl which terminates in a small labral tooth; **B, C** = front and back macro images of protoconch.

Figure 5. *F. corteziana* Berschauer, Petuch & Clark, new species, specimen with an anemone which appears to be *Anthothoe carcinophila* (Verrill, 1869) trawled at 140 m depth in the Wagner Basin, northern Sea of Cortez, Mexico.